

# Nuclear Science Training Course with Nucleonica

## Mass Activity Converter

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The screenshot shows the Nucleonica web application interface. At the top, the logo and tagline "... web driven nuclear science" are visible. Below the navigation bar, the "Mass Activity Converter" section is active, showing "27 Cobalt" and "Current Chart: Karlsruhe". The input fields show "Element: Co" and "Mass: 60". The "Quantity" field is set to "1E+06" and the "Unit" is "Activity (Bq)". The "Convert" button is present. Below the input fields, a table displays various physical quantities and their corresponding magnitudes and units.

Physical quantity	Magnitude	Unit
Mass	$M = 2.388e-8$	g
Activity	$A = 1.000e+6$	Bq
Activity	$A = 6.000e+7$	dpm
Number of atoms	$N = 2.400e+14$	
Number of moles	$N/N_A = 3.985e-10$	
Exposure rate at 2 m	$\dot{X} = 0.07522$	
Equivalent gamma dose rate in tissue at 2 m	$\dot{H} = 0.08425$	
Committed Effective Dose Equivalent, inhalation	$E_{50} = 3100$	r
Committed Effective Dose Equivalent, ingestion	$E_{50} = 340$	m
Isotopic Power $\alpha$	$P_{\alpha} = 0$	W
Isotopic Power $\alpha+\beta$	$P_{\alpha\beta} = 1.548e-8$	W
Isotopic Power $\alpha+\beta+\gamma$	$P_{\alpha\beta\gamma} = 4.161e-7$	W

# Mass Activity Converter

- Learning objectives
- User interface

Element info.

Wiki help

Nuclide selector

Nuclide Chart icon

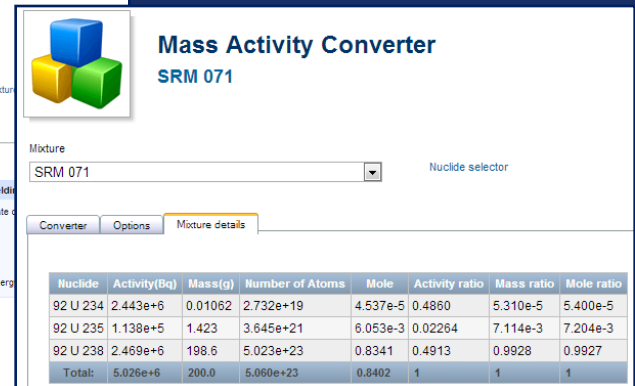
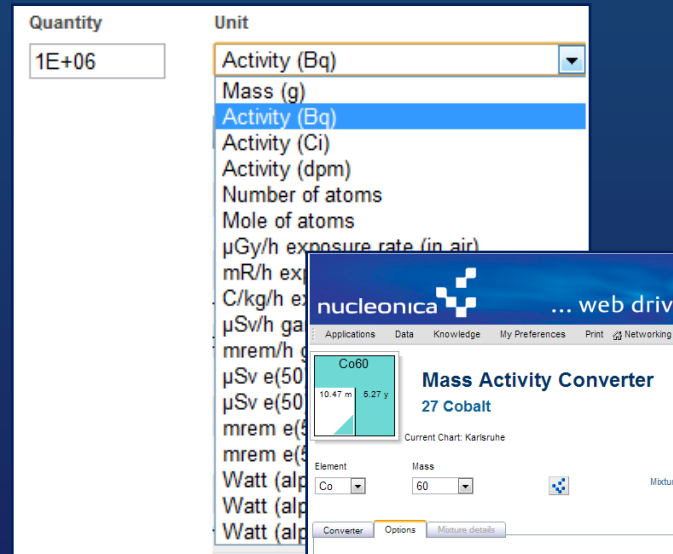
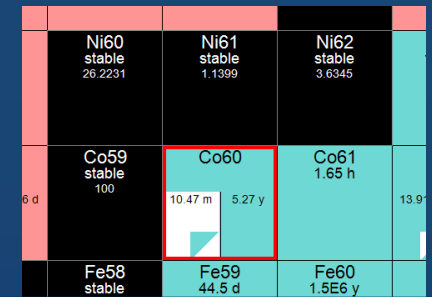
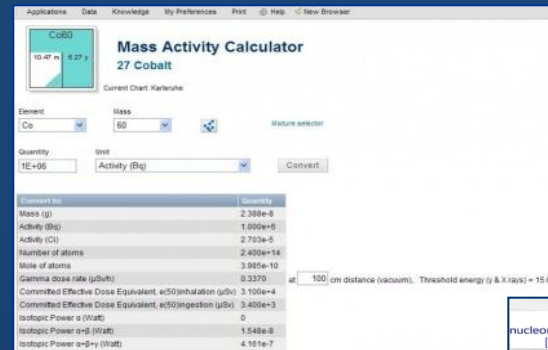
Mixtures

Convertor

Options

Mixtures

- Exercises



## Learning Objectives

- To become familiar with basic radiological units becquerel (Bq), curie (Ci), sievert (Sv), etc.
- To become familiar with basic radiological quantities such as activity, specific activity, dose rate, etc.
- To understand the relationships between the basic units
- To get to know how to use the Mass Activity Converter module in Nucleonica to convert between different units. This requires familiarity with the Glossary, Help, Calculator
- How to use mixtures
- To strengthen the above understanding through a series of problems and exercises.



# Overview...

The mass activity calculator is a popular tool for conversion between different physical quantities (e.g. mass, activity, number of atoms, etc.).

- external and internal dosimetry quantities such as the gamma dose rate (where the distance is required)
- the committed effective doses for inhalation and ingestion.
- the amount of heat generated – isotopic power – through radioactive decay for  $\alpha$ ,  $\alpha+\beta$ , and  $\alpha+\beta+\gamma$ .

In the this example, the nuclide Co-60 is selected. A different nuclide can be selected from the element and mass drop-down menus. The default source strength is 1 MBq. In the unit drop-down menu, the source strength is shown in becquerel (Bq), curie (Ci), number of atoms, etc. The user can also select a previously defined nuclide mixture (by clicking on the Mixture selector). Further information is given in the Nucleonica wiki.

Co60

10.47 m 5.27 y

## Mass Activity Converter

### 27 Cobalt


Current Chart: Karlsruhe

Element

Mass

Co

60



Mixture selector

Converter

Options

Mixture details

Quantity

Unit

1E+06

Activity (Bq)

Convert

Physical quantity	Magnitude	Unit
Mass	M = 2.388e-8	g
Activity	A = 2.703e-5	Ci
Number of atoms	N = 2.400e+14	atom
Number of moles	N/N <sub>A</sub> = 3.985e-10	mole
Exposure rate at 2 m	X = 0.07522	μGy/h in air
Equivalent gamma dose rate in tissue at 2 m	H = 0.08425	μSv/h
Committed Effective Dose Equivalent, inhalation	E <sub>50</sub> = 3.100e+3	mrem
Committed Effective Dose Equivalent, ingestion	E <sub>50</sub> = 340.0	mrem
Isotopic Power α	P <sub>α</sub> = 0	Watt
Isotopic Power α+β	P <sub>αβ</sub> = 1.548e-8	Watt
Isotopic Power α+β+γ	P <sub>αβγ</sub> = 4.161e-7	Watt

# Element information...

nucleonica

... web driven nuclear science

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Co60

10.47 m

27 y

Mass Activity Converter

27 Cobalt

Current Chart: Karlsruhe

ElementMassMixture selector

Co6060

ConverterOptionsMixture details

QuantityUnitConvertSignificant figures: 4

1E+06Activity (Bq)

Physical quantity	Magnitude	Unit
Mass	M = 2.388e-8	g
Activity	A = 1.000e+6	Bq
Activity	A = 6.000e+7	dpm
Number of atoms	N = 2.400e+14	atom
Number of moles	N / N <sub>A</sub> = 3.985e-10	mole
Exposure rate at 2 m	$\dot{X}$ = 0.07522	μGy/h in air
Equivalent gamma dose rate in tissue at 2 m	$\dot{H}$ = 0.08425	μSv/h
Committed Effective Dose Equivalent, inhalation	E <sub>50</sub> = 3100	mrem
Committed Effective Dose Equivalent, ingestion	E <sub>50</sub> = 340	mrem
Isotopic Power α	P <sub>α</sub> = 0	Watt
Isotopic Power α+β	P <sub>αβ</sub> = 1.548e-8	Watt
Isotopic Power α+β+γ	P <sub>αβγ</sub> = 4.161e-7	Watt

www.nucleonica.com/wiki/index.php?title=Cobalt\_Co

page discussion view source history

nucleonica [wiki]

Cobalt Co

Cobalt

(Kobald, from the German, goblin or evil spirit, cobalos, Greek, mine). Discovered by Brand about 1735. Cobalt occurs in the mineral cobaltite, smaltite, and erythrite, and is often associated with nickel, silver, lead, copper, and iron ores, from which it is most frequently obtained as a by-product. It is also present in meteorites. Important ore deposits are found in Zaire, Morocco, and Canada. The U.S. Geological Survey has announced that the bottom of the north central Pacific Ocean may have cobalt-rich deposits at relatively shallow depths in water close to the Hawaiian Islands and other U.S. Pacific territories. Cobalt is a brittle, hard metal, closely resembling iron and nickel in appearance. It has a metallic permeability of about two thirds that of iron. Cobalt tends to exist as a mixture of two allotropes over a wide temperature range; the β-form predominates below 400 C, and the α-form above that temperature. The transformation is sluggish and accounts in part for the wide variation in reported data on physical properties of cobalt. It is alloyed with iron, nickel and other metals to make Alnico, an alloy of unusual magnetic strength with many important uses. Stellite alloys, containing cobalt, chromium, and tungsten, are used for high-speed, heavy-duty, high temperature cutting tools, and for dies. Cobalt is also used in other magnetic steels and stainless steels and in alloys used in jet turbines and gas turbine generators. The metal is used in electroplating because of its appearance, hardness, and resistance to oxidation. The salts have been used for centuries for the production of brilliant and permanent blue colors in porcelain, glass, pottery, tiles, and enamels. It is the principal ingredient in Sevre's and Thenard's blue. A solution of the chloride is used as a sympathetic ink. The cobalt amines are of interest; the oxide and the nitrate are important. Cobalt carefully used in the form of the chloride, sulfate, acetate, or nitrate has been found effective in correcting a certain mineral deficiency disease in animals. Soils should contain 0.13 to 0.30 ppm of cobalt for proper animal nutrition. Cobalt-60, an artificial isotope, is an important gamma ray source, and is extensively used as a tracer and a radiotherapeutic agent. Exposure to cobalt (metal fume and dust) should be limited to 0.05 mg/m<sup>3</sup> (8-hour time-weighted average 40-hour week).

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Co60  
10.47 m 5.27 y

## Mass Activity Converter

### 27 Cobalt

Current Chart: Karlsruhe

Element: Co Mass: 60 Mixture selector

Converter Options Mixture details

Quantity: 1E+06 Unit: Activity (Bq) Convert

Physical quantity	Magnitude	Unit
Mass	$M = 2.388\text{e-}8$	g
Activity	$A = 1.000\text{e+}6$	Bq
Activity	$A = 6.000\text{e+}7$	dpm
Number of atoms	$N = 2.400\text{e+}14$	atom
Number of moles	$N / N_A = 3.985\text{e-}10$	mol
Exposure rate at 2 m	$\dot{X} = 0.07522$	$\mu\text{Gy}$
Equivalent gamma dose rate in tissue at 2 m	$\dot{H} = 0.08425$	$\mu\text{Sv}$
Committed Effective Dose Equivalent, inhalation	$E_{50} = 3100$	mrem
Committed Effective Dose Equivalent, ingestion	$E_{50} = 340$	mrem
Isotopic Power $\alpha$	$P_{\alpha} = 0$	Watt
Isotopic Power $\alpha+\beta$	$P_{\alpha\beta} = 1.548\text{e-}8$	Watt
Isotopic Power $\alpha+\beta+\gamma$	$P_{\alpha\beta\gamma} = 4.161\text{e-}7$	Watt

Help:Mass Activity Converter

Level: Introductory, Intermediate

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  - 4.7 Simple Decay and the Decay Constant
- 5 Exercises
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Nucleonica's Mass Activity Converter

The mass activity converter is a popular tool for conversion between different physical quantities (e.g. mass, activity, number of atoms, etc.). A particularly useful feature is that in addition to single nuclides, the mass activity calculator can also be applied to nucleide mixtures. These nucleide mixtures can be created with the Nucleide Mixtures module. The Convert box shows the full list of quantities. In addition to the standard list (mass, activities, etc.), conversions can also be made using:

- external and internal dosimetry quantities such as the gamma dose rate (where the distance is required)
- the committed effective doses for inhalation and ingestion.
- the amount of heat generated – isotopic power – through radioactive decay for  $\alpha$ ,  $\alpha+\beta$ ,  $\alpha+\beta+\gamma$ .

In the above example, the nuclide Co-60 is selected. A different nuclide can be selected from the element and mass drop-down menus. The default source strength is 1 MBq. In the above example, the source strength is shown in the table below.

Co60  
10.47 m 5.27 y

## Mass Activity Converter

### 27 Cobalt

Current Chart: Karlsruhe

Element: Co Mass: 60 Mixture selector

Converter Options Mixture details

Quantity: 1E+06 Unit: Activity (Bq) Convert

Physical quantity	Magnitude	Unit
Mass	$M = 2.388\text{e-}8$	g
Activity	$A = 1.000\text{e+}6$	Bq
Activity	$A = 6.000\text{e+}7$	dpm
Number of atoms	$N = 2.400\text{e+}14$	atom
Number of moles	$N / N_A = 3.985\text{e-}10$	mol
Exposure rate at 2 m	$\dot{X} = 0.07522$	$\mu\text{Gy}$
Equivalent gamma dose rate in tissue at 2 m	$\dot{H} = 0.08425$	$\mu\text{Sv}$
Committed Effective Dose Equivalent, inhalation	$E_{50} = 3100$	mrem
Committed Effective Dose Equivalent, ingestion	$E_{50} = 340$	mrem
Isotopic Power $\alpha$	$P_{\alpha} = 0$	Watt
Isotopic Power $\alpha+\beta$	$P_{\alpha\beta} = 1.548\text{e-}8$	Watt
Isotopic Power $\alpha+\beta+\gamma$	$P_{\alpha\beta\gamma} = 4.161\text{e-}7$	Watt

## Wiki Help: Basic Quantities and Relations

In this section, the basic relationships between number of atoms, mass, and activity, are developed. From the basic quantities, additional quantities such as the gamma dose rate, the effective doses for inhalation and ingestion and the isotopic powers can be obtained.

For an amount of material with mass in grams given by  $Mass(g)$ , the number of atoms  $N$  is given by

$$\frac{N}{N_A} = \frac{Mass(g)}{M} \quad \text{or} \quad N = Mass(g) \cdot \frac{N_A}{M}$$

Where  $N_A$  is Avogadro's number or Avogadro's constant ( $N_A = 6.002214179 \times 10^{23}$ ), and  $M$  is the atomic mass of the nuclide. This basic relationship follows from the fact that 1 mole of any material contains Avogadro's number of atom.

The conversion of number of atoms to the number of moles is given by

$$\text{Number of moles} = \frac{N}{N_A}$$

The conversion from number of atoms to activity, and vice versa, is obtained using

$$Activity(Bq) = k \cdot N = \ln 2 \cdot N / \tau$$

$$Activity(Ci) = Activity(Bq) / 3.7 \cdot 10^{10}$$

Where  $k$ , and  $\tau$  are the decay constant and half-life respectively of the nuclide. Combining the above relations it follows that the relation between activity and mass is given by

$$Activity(Bq) = \frac{Mass(g) \cdot N_A \cdot \ln 2}{M \cdot \tau}$$

## Wiki Help: Derived Quantities

From the activity  $A$ , additional important quantities such as the gamma dose rate, the committed effective dose, and the isotopic powers can be derived. The relations used in the Mass Activity Calculator are given below. For more details on the meaning and derivation of these quantities, the reader should follow the links.

The gamma dose rate in tissue,  $dH/dt$ , (follow the link for the derivation) is given by

$$\frac{dH}{dt} = A / (4\pi R^2) \cdot \sum_i (E_i \cdot P_i \cdot (\mu_i / \rho)_i^{tis})$$

From the above relation, it can be seen that the gamma dose rate depends on the distance  $R$  from the source, this reason, for the evaluation of the gamma dose rate, the distance must also be specified. A default distance 100 cm is used. In addition, the threshold energy must also be specified. The default value of the threshold energy is 15 keV. Other quantities required for the calculation are the energies  $E_i$  and emission probabilities of the radiation, and the mass absorption coefficient  $(\mu/\rho)_i^{tis}$  in tissue. The summation index  $i$  refers to all the individual gamma and x-ray energies.

The committed effective doses are given by

$$\text{Committed effective dose for inhalation, } E_{mh}(50) = e_{mh}(50) \cdot \text{Activity}(Bq)$$

$$\text{Committed effective dose for ingestion, } E_{mg}(50) = e_{mg}(50) \cdot \text{Activity}(Bq)$$

Finally, the isotopic power is given by

$$\text{Isotopic Power } (\alpha) = A \cdot |E_\alpha|$$

$$\text{Isotopic Power } (\alpha + \beta) = A \cdot |E_\alpha + E_\beta|$$

$$\text{Isotopic Power } (\alpha + \beta + \gamma) = A \cdot |E_\alpha + E_\beta + E_\gamma|$$



# Nuclide Selector

Element

Co
Ar
As
At
Au
B
Ba
Be
Bh
Bi
Bk
Br
C
Ca
Cd
Ce
Cf
Cl
Cm
Cn
Co

Mass

47
47
48
49
50
51
52
52m
53
53m
54
54m
55
56
57
58
58m
59 s
60
60m
61

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Co60
10.47 m
5.27 y

## Mass Activity Converter

### 27 Cobalt

Current Chart: Karlsruhe

Element

Co

Mass

60

Mixture selector

Converter
Options
Mixture details

Quantity

1E+06

Unit

Activity (Bq)

Convert

Significant figures:

4

Physical quantity	Magnitude	Unit
Mass	$M = 2.388e-8$	g
Activity	$A = 1.000e+6$	Bq
Activity	$A = 6.000e+7$	dpm
Number of atoms	$N = 2.400e+14$	atom
Number of moles	$N / N_A = 3.985e-10$	mole
Exposure rate at 2 m	$\dot{X} = 0.07522$	$\mu\text{Gy/h in air}$
Equivalent gamma dose rate in tissue at 2 m	$\dot{H} = 0.08425$	$\mu\text{Sv/h}$
Committed Effective Dose Equivalent, inhalation	$E_{50} = 3100$	mrem
Committed Effective Dose Equivalent, ingestion	$E_{50} = 340$	mrem
Isotopic Power $\alpha$	$P_{\alpha} = 0$	Watt
Isotopic Power $\alpha+\beta$	$P_{\alpha\beta} = 1.548e-8$	Watt
Isotopic Power $\alpha+\beta+\gamma$	$P_{\alpha\beta\gamma} = 4.161e-7$	Watt

## Nuclide Chart icon

The Nuclide Chart icon shows the location of the selected nuclide on the nuclide chart. To the right of this, the nuclide mixture link can be used to select a nuclide mixture.

The source strength can be specified by using the drop-down menus (see the following section). The default source strength is 1 MBq.

In the Unit/Quantity drop-down menus, the source strength is shown in becquerel (Bq), curie (Ci), number of atoms, etc. This can then be converted to other units.

**Co60**  
10.47 m 5.27 y

### Mass Activity Converter

27 Cobalt

Current Chart: Karlsruhe

Element: Co Mass: 60

Mixture selector


Converter Options Mixture details

Quantity: 1E+06 Unit: Activity (Bq) Convert


Physical quantity	Unit
Mass	g
Activity	Bq

Ni60 stable 26.2231	Ni61 stable 1.1399	Ni62 stable 3.6345
Co59 stable 100	Co60 10.47 m 5.27 y	Co61 1.65 h
Fe58 stable 0.282	Fe59 44.5 d	Fe60 1.5E6 y

# Nuclide Mixtures

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 **Mass Activity Converter**  
SRM 071

Mixture  
SRM 071 nuclide selector

Quantity Unit  
5.02584e+6 Activity (Bq) Convert Significant figures: 4

Physical quantity	Magnitude	Unit
Mass	M = 200.0	g
Activity	A = 5.026e+6	Bq
Activity	A = 3.016e+8	dpm
Number of atoms	N = 5.060e+23	atom

Mixture

Natural Potassium

"Cs-137"

"U-238"

1 g irradiated UOX fuel

1 ton Spent Fuel with thorium

1g UOX spent fuel, 36 y decay

20% enriched U

Ce-144 / Pr-144

Cm 01

Cm mixture

Cr element

CR\_1-MAPu\_1-Fabr-2051-Cesar\_5

CR\_1-MAPu\_1-Fabr-2151-Cesar\_5

CR\_1-MAPu\_1-Fabr-2151-Cesar\_5-1

CR\_1-MAPu\_1-Fabr-2151-Cesar\_5-2

Cs137 / Ba137m

Cs137 in equilibrium with Ba137m

Decay of 100 Grams of 92 U 238 after 4.46808e+10 Years(0.01)

Decay of 1e6 Becquerel of 55 Cs 137 after 1 Hours(1E-02)

Decay of 5.9815e+6 Becquerel of Natural Uranium after 1.15E+01 Years(5.400e-

# Converter

Co60

10.47 m 5.27 y

Mass Activity Converter

27 Cobalt

Current Chart: Karlsruhe

Element

Co

Mass

60

Mixture selector

Converter

Options

Mixture details

Quantity

1E+06

Unit

Activity (Bq)

Convert

Physical quantity	Magnitude	Unit
Mass	M = 2.388e-8	g
Activity	A = 2.703e-5	Ci
Number of atoms	N = 2.400e+14	atom
Number of moles	N/N <sub>A</sub> = 3.985e-10	mole
Exposure rate at 2 m	X = 0.07522	μGy/h in air
Equivalent gamma dose rate in tissue at 2 m	H = 0.08425	μSv/h
Committed Effective Dose Equivalent, inhalation	E <sub>50</sub> = 3.100e+3	mrem
Committed Effective Dose Equivalent, ingestion	E <sub>50</sub> = 340.0	mrem
Isotopic Power α	P <sub>α</sub> = 0	Watt
Isotopic Power α+β	P <sub>αβ</sub> = 1.548e-8	Watt
Isotopic Power α+β+γ	P <sub>αβγ</sub> = 4.161e-7	Watt

The input unit can be changed in the Unit drop down menu. The default unit is Bq. Had the value Ci been selected, on pressing the Convert button, the corresponding values in grams, Bq, number of atoms etc. are shown in the Convert to/Quantity table.

Quantity

1E+06

Unit

Activity (Bq)

Mass (g)

Activity (Bq)

Activity (Ci)

Activity (dpm)

Number of atoms

Mole of atoms

μGy/h exposure rate (in air)

mR/h exposure rate

C/kg/h exposure rate

μSv/h gamma dose rate

mrem/h gamma dose rate

μSv e(50)inh

μSv e(50)ing

mrem e(50)inh

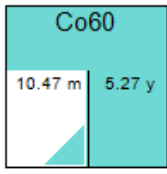
mrem e(50)ing

Watt (alpha)

Watt (alpha+beta)

Once the unit and quantity have been selected in the Unit/Quantity Selector, the source strength in other units is given in the physical quantity table, by pressing the Convert button. The results are shown for 1 MBq Co-60.


# Options



## Mass Activity Converter

### 27 Cobalt

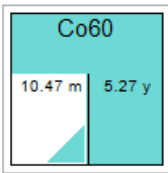
Current Chart: Karlsruhe

Element: Co Mass: 60  Mixture selector

**Options** (highlighted with a red circle)

Quantity: 1E+06 Unit: Activity (Bq) Convert


Physical quantity	Magnitude	Unit
Mass	$M = 2.388\text{e-}8$	g
Activity	$A = 2.703\text{e-}5$	Ci
Number of atoms	$N = 2.400\text{e+}14$	atom
Number of moles	$N/N_A = 3.985\text{e-}10$	mole
Exposure rate at 2 m	$X = 0.07522$	$\mu\text{Gy/h in air}$
Equivalent gamma dose rate in tissue at 2 m	$\dot{H} = 0.08425$	$\mu\text{Sv/h}$
Committed Effective Dose Equivalent, inhalation	$E_{50} = 3.100\text{e+}3$	mrem
Committed Effective Dose Equivalent, ingestion	$E_{50} = 340.0$	mrem
Isotopic Power $\alpha$	$P_\alpha = 0$	Watt
Isotopic Power $\alpha+\beta$	$P_{\alpha\beta} = 1.548\text{e-}8$	Watt
Isotopic Power $\alpha+\beta+\gamma$	$P_{\alpha\beta\gamma} = 4.161\text{e-}7$	Watt



## Mass Activity Converter

### 27 Cobalt

Current Chart: Karlsruhe

Element: Co Mass: 60  Mixture selector

**Options** (highlighted with a red circle)

Quantity: 1E+06 Unit: Activity (Bq) Convert

Quantity	Unit
Activity	<input type="radio"/> Ci <input checked="" type="radio"/> dpm
Exposure Rate	<input checked="" type="radio"/> $\mu\text{Gy/h in air}$ <input type="radio"/> C/kg/h in air <input type="radio"/> mR/h in air
Dose rate	<input type="radio"/> $\mu\text{Gy/h}$ <input type="radio"/> mrad/h <input checked="" type="radio"/> $\mu\text{Sv/h}$ <input type="radio"/> mrem/h
Effective Dose	<input type="radio"/> $\mu\text{Sv}$ <input checked="" type="radio"/> mrem

#### Dosimetry and Shielding Settings

Exposure and dose rate calculation:

- Distance: 200 cm
- Medium: vacuum
- Radiations:  $\gamma$  & X rays
- Threshold energy: 15 keV

Save to my defaults Reset my defaults Reset Nucleonica defaults



# Mixtures

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**Mass Activity Converter**  
SRM 071

Mixture: SRM 071 Nuclide selector

Quantity: 5.02584e+6 Unit: Activity (Bq) Convert

Converter Options **Mixture details**

Physical quantity	Magnitude	Unit
Mass	M = 200.0	g
Activity	A = 5.026e+6	Bq
Activity	A = 3.016e+8	dpm
Number of atoms	N = 5.060e+23	atom
Number of moles	N/N <sub>A</sub> = 0.8402	mole
Exposure rate at 2 m	$\dot{X}$ = 5.481e-4	μGy/h in air
Equivalent gamma dose rate in tissue at 2 m	$\dot{H}$ = 6.139e-4	μSv/h
Committed Effective Dose Equivalent, inhalation	E <sub>50</sub> = 4.368e+6	mrem
Committed Effective Dose Equivalent, ingestion	E <sub>50</sub> = 2.362e+4	mrem
Isotopic Power α	P <sub>α</sub> = 3.660e-6	Watt
Isotopic Power α+β	P <sub>αβ</sub> = 3.670e-6	Watt
Isotopic Power α+β+γ	P <sub>αβγ</sub> = 3.674e-6	Watt
Spontaneous fission neutron emission rate	$\dot{n}$ = 2.697	n/s

**Mass Activity Converter**  
SRM 071

Mixture: SRM 071 Nuclide selector

Converter Options **Mixture details**


Nuclide	Activity(Bq)	Mass(g)	Number of Atoms	Mole	Activity ratio	Mass ratio	Mole ratio
92 U 234	2.443e+6	0.01062	2.732e+19	4.537e-5	0.4860	5.310e-5	5.400e-5
92 U 235	1.138e+5	1.423	3.645e+21	6.053e-3	0.02264	7.114e-3	7.204e-3
92 U 238	2.469e+6	198.6	5.023e+23	0.8341	0.4913	0.9928	0.9927
Total	5.026e+6			0.8402			

# Nuclide Mixtures

The mass activity calculator can also be used for nuclide mixtures. In the diagram shown, the nuclide mixture “natural uranium” has been selected. This mixture has been previously created in the Nuclide Mixtures module for 1 mole (of atoms) of natural uranium containing

0.9927 mole U-238,  
 $7.114 \times 10^{-3}$  mole U-235 and  
 $5.310 \times 10^{-5}$  mole U-234.

As can be seen, even 1 mole of atoms of natural uranium, with a mass of 238 gram and activity of almost 6 MBq (without daughters), has a negligible gamma dose rate and heat emission rate (isotopic power).



## Mass Activity Converter

### Natural Uranium

Mixture  

Natural Uranium

Nuclide selector

Converter

Options

Mixture details

Quantity

Unit

1

Mole of atoms

Convert

Physical quantity	Magnitude	Unit
Mass	M = 238.0	g
Activity	A = 5.981e+6	Bq
Activity	A = 3.589e+8	dpm
Number of atoms	N = 6.022e+23	atom
Number of moles	N / N <sub>A</sub> = 1.000	mole
Exposure rate at 2 m	$\dot{X}$ = 6.523e-4	μGy/h in air
Equivalent gamma dose rate in tissue at 2 m	$\dot{H}$ = 7.306e-4	μSv/h
Committed Effective Dose Equivalent, inhalation	E <sub>50</sub> = 5.199e+6	mrem
Committed Effective Dose Equivalent, ingestion	E <sub>50</sub> = 2.811e+4	mrem
Isotopic Power α	P <sub>α</sub> = 4.356e-6	Watt
Isotopic Power α+β	P <sub>αβ</sub> = 4.368e-6	Watt
Isotopic Power α+β+γ	P <sub>αβγ</sub> = 4.373e-6	Watt
Spontaneous fission neutron emission rate	$\dot{n}$ = 3.209	n/s

# Mass Activity Converter

- Learning objectives
- User interface

Element info.

Wiki help

Nuclide selector

Nuclide Chart icon

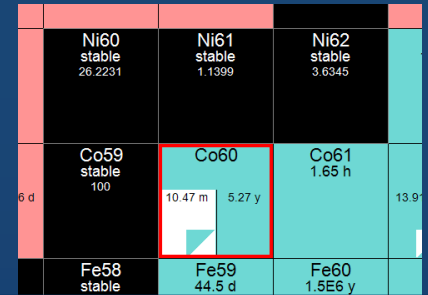
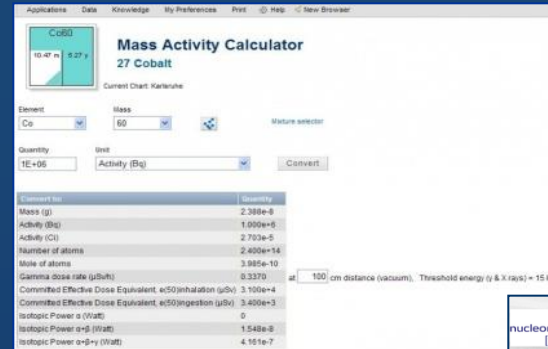
Mixtures

Convertor

Options

Mixtures

- Exercises



**Quantity** 1E+06 **Unit** Activity (Bq)

Mass (g)  
Activity (Ci)  
Activity (dpm)  
Number of atoms  
Mole of atoms  
μGy/h exposure rate (in air)  
mR/h exposure rate (in air)  
C/kg/h exposure rate (in air)  
μSv/h gamma dose rate (in air)  
mrem/h gamma dose rate (in air)  
μSv e(50) gamma dose rate (in air)  
mrem e(50) gamma dose rate (in air)  
Watt (alpha-beta)  
Watt (alpha-beta-gamma)  
Watt (alpha-beta-gamma-neutrinos)

**nucleonica** ... web driven

**Mass Activity Converter**  
27 Cobalt

Current Chart: Karlsruhe

Element: Co Mass: 60 Mixture selector

Convertor Options Mixture details

**Help:Mass Activity Converter**

Level: Introductory, Intermediate

**Contents**

1. Nucleonica's Mass Activity Converter
2. Did You Know?
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4. Using the Module
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**Nucleonica's Mass Activity Converter**

The mass activity converter is a popular tool for conversion between different physical quantities (e.g. mass, activity, number of atoms, etc.). A particularly useful feature is that in addition to single nuclides, the mass activity calculator can also be applied to nuclide mixtures. These nuclide mixtures can be created with the Nucleonica's Mixtures module. The Converter shows the full list of quantities. In addition to the standard list (mass, activities, etc.), conversions can also be made using:

- external and internal dosimetry quantities such as the gamma dose rate (where the distance is required)
- the committed effective doses for inhalation and ingestion
- the amount of heat generated - isotopic power - through radioactive decay for α, β, γ, and n

In the above example, the nuclide Co-60 is selected. A different nuclide can be selected from the element and mass drop-down menus. The default source strength is 1 MBq. In the unit drop-down menu, the source strength is shown in becquerel (Bq), curie (Ci), number of atoms, etc. The user can also select a

**Mass Activity Converter**  
SRM 071

Mixture: SRM 071 Nuclide selector

Convertor Options Mixture details

Nuclide	Activity(Bq)	Mass(g)	Number of Atoms	Mole	Activity ratio	Mass ratio	Mole ratio
92 U 234	2.443e+6	0.01062	2.732e+19	4.537e-5	0.4860	5.310e-5	5.400e-5
92 U 235	1.138e+5	1.423	3.645e+21	6.053e-3	0.02264	7.114e-3	7.204e-3
92 U 238	2.469e+6	198.6	5.023e+23	0.8341	0.4913	0.9928	0.9927
<b>Total:</b>	<b>5.026e+6</b>	<b>200.0</b>	<b>5.060e+23</b>	<b>0.8402</b>	<b>1</b>	<b>1</b>	<b>1</b>

# Exercises Mass Activity Converter

1. **Calculate the specific activities of C-14 and S-35?** ( $1.7\text{E}11$  Bq/g ( $4.5$  Ci/g),  $1.6\text{E}15$  Bq/g ( $4.3\text{E}4$  Ci/g)).
2. **The activity of Sr-90 is 18,000 transformations per minute. What is the mass of Sr-90?** (mass =  $5.87\text{E}-11\text{g}$ ).
3. **Six grams of carbon from a piece of wood found in an ancient temple are analysed and found to have an activity of 10 transformations per minute per gram of carbon. How many atoms of C-14 are present in the sample and what is their mass?** ( $2.6\text{E}11$  atoms, mass =  $6.0\text{E}-12$  g)
4. **What is the dose rate from a 100 MBq source of Co-60 at 2m distance?** ( $8.4$   $\mu\text{Sv/h}$ )
5. **How many grams of Y-90 are in secular equilibrium with 1 mg Sr-90?** ( $0.25$   $\mu\text{g}$ )
6. **The environmental burden of C-14 is as follows: in the atmosphere 4 MCi, in plants 13 MCi, in the oceans 240 MCi. What are the masses of C-14 in a) the atmosphere, b) in plants, c) in the oceans?**  
(893 kg, 2.9 metric tonnes, 53.6 tonnes)

## 7. Consider the nuclide mixture „Juelich file“ containing 65 nuclides

- What is the total activity and mass? ( $1.39 \times 10^{10}$  Bq, 2562 g)
- What is the total gamma dose rate at 1m? ( $114 \mu\text{Sv/h}$ )
- What is the total neutron emission rate? (116.7 neutrons per second)
- What is the total amount of heat produced? ( $5.877 \times 10^{-4}$  W)
- Which nuclide has the highest activity? (Sr-90)
- Which nuclide has the highest mass? (U-238)



## Exercises Mass Activity Converter

**8. It is suspected that a radioactive sample contains HEU. The gamma dose rate at 3 cm is 2  $\mu\text{Sv/h}$  (without shielding).**

- **What is the mass of HEU giving rise to this dose rate? (1.165g).**

**The neutron emission rate is measured to be 1 n /s. What can you conclude about the radioactive source? (It is not HEU)**

**9. The concentration of potassium (K) in humans is about 1.7 g/kg. What mass of potassium does an average person (weight 80 kg) contain? (136 g).**

- **What is the atomic weight of potassium? Hint: see the sample mixture in the Nuclide Mixtures (39.0983)**
- **What is the total number of atoms of potassium? (2.09E24 atoms)**
- **What is the total number of atoms of K-40? (2.45E20 atoms K-40).  
What is the abundance of K-40? (0.0117 atom%)**
- **What is the mass and activity of K-40 in this person? (1.63E-2 g, 4.26 kBq).**